Evaluation of Occupational Dust Control Technology in Cottonseed Oil Mills[1]

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ABSTRACT

Occupational cotton dust control technology was evaluated in 10 oil mills throughout the cotton belt of the U.S. This evaluation was restricted to mechanical portions of each mill: seed cleaning, delintering, hulling and separating, and linter baling. Based on the process machinery observed in these mills, a 500 ton/day model cottonseed oil mill was designed. The occupational dust control systems for this mill were based on current state-of-the-art technology observed during this project. Further improvements based on readily available air pollution control devices have been incorporated. In order to achieve minimal respirable dust concentrations in the mill, all dust emission points have been enclosed to the maximal extent consistent with efficient plant operations. The various processing areas in the mill were designed with negative pressure dust control systems separate from the general ventilation system. The dust control system includes coarse dust removal by high-efficiency cyclones whose effluent discharges into pulse-jet fabric filter baghouses operated at an air-to-cloth ratio of 20:1. The emission control system for saw-type delinter systems were divided into small units to reduce the deleterious effects of fires.

INTRODUCTION

Cotton dust is defined as "dust present during the handling or processing of cotton which may contain a mixture of substances including ground-up plant matter, fiber, bacteria, fungi, soil, pesticides, non-plant matter and other contaminants which may have accumulated during the growing, harvesting and subsequent processing or storage" (1). The action of this dust on the human respiratory passages can result in the development of byssinosis. At the time this research program was initiated in September 1979, the proposed permissible exposure limit for cotton dust in cottonseed oil mills was 0.5 mg of lint-free, respirable dust per cubic meter of air as sampled by the vertical elutriator (1).

Objectives

Cotton dust has long been accepted as an essential cause of byssinosis among exposed workers in cotton textile mills and gins. Therefore, the objectives of this study were: to define the best available occupational dust control technology in current use in cottonseed oil mills; to define a model cottonseed oil mill equipped with an occupational dust control system based on the information just mentioned; and to provide an economic analysis of the model dust control system. This paper addresses the first 2 objectives. Objective 3 is treated elsewhere (2).

Approach

In order to provide the necessary information, a survey was made to evaluate the dust control systems in cottonseed oil mills throughout the Cotton Belt of the U.S. Oil mills processing irrigated and dry-land stripper-harvested cotton were evaluated. Emissions at mills processing irrigated and rain-belt cotton which had been machine-picked were also sampled. No attempt was made to compare the effects of all these cultivar- and growth-related variables. Instead, the respirable dust levels as determined by the vertical elutriator were measured in each mechanical processing area: cleaning, delintering, hulling/separating and baling. The dust levels of these 4 areas in each of the 10 mills that were sampled are shown in Table I. Few areas in any one mill met the proposed standard of 0.5 mg/m^3. The average concentration of elutriated dust in each area was in excess of the proposed standard value by a factor of 2-6. The data also indicated that current processing equipment designs do not prevent dust emissions to a satisfactory degree. Therefore, the need for a dust control system to reduce these emissions is obvious. The turnout per ton of raw seed processed is shown in Table II for 9 of the 10 mills visited for oil, meal, hulls, various linter grades and losses.

Dust Sampling

The approach used to obtain data during the mill visits began with a walk-through inspection with either the mill manager, superintendent, or engineer. The result of this 3-4-hr inspection resulted in a process flow sheet describing each mill. During the inspection, the work stations were identified by management. Sampler locations were selected to be as near the work stations as possible without causing disruption of mill operations. Throughout all sampling periods, the elutriators were kept under rotating observation to preclude tampering. During this time, the sampling crew also collected samples of the raw seed and intermediate products as well as trash streams throughout the mill for assessment of the fate of bract and leaf-like particles as reported elsewhere (3). They also observed and reported on work practices in each processing area.

Two standard verticle elutriators were used to determine the concentration of respirable dust in each of the various work areas. Sampling was conducted following the procedures of 29 CFR 1910.1043 as published in the *Federal Register*, Vol. 43, no. 122, pp. 27398-27399 of June 23, 1978. OSHA compliance sampling was not conducted in any mill. Sampling times were generally 200-400 min in each location, depending on visual assessment of the dust level. The samples for calculating time-weighted respirable dust concentrations were obtained using 5-μm pore diameter, 37 mm polyvinyl chloride (Gelman Metricel®) filters in polystyrene cassettes with cellulose back-up pads. Samples were also obtained in identical locations for particle size determination by electronic image analysis techniques. Those samples were collected over 10-60-min periods (as required by that technique) on polycarbonate (Nuclepore Corp.) or nitrocellulose (Gelman Corp.) filters as required. Those results are reported elsewhere (4).

After concluding the sampling, the process flow diagrams were verified with management. Samples of the raw

[1]In order to conserve space, Figures 4, 5, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 29 and 30 are not shown, even though they are referenced in the text. Readers desiring copies of these may obtain them at reproduction costs from the authors.

TABLE I

Time Weighted Elutriated Dust Concentrations (mg/m³)

Mill	Cleaning	Delintering	Hulling	Baling
A	1.460	1.509	0.693	1.271
B	2.183	1.164	1.040	1.437
C	2.408	1.836[a]	7.890 (before) 3.133 (after)	1.031
D	7.925 (set 1)	3.198 (set 1)[a] 2.305 (1st cut, set 2) 2.073 (2nd cut, set 2)	3.504 (set 1)	1.343 (set 1) 2.667 (set 2)
E	4.610[b]	0.752 (2nd cut)	0.735	0.071
F	1.096 (set 1) 1.139 (set 2)	0.603 (set 1) 1.078 (set 2)	0.851 (set 1) 0.627 (set 2)	0.291 (set 1)
G	0.478 (set 1) 0.846 (set 2)	 0.439 (set 2)	1.911 (set 1) 1.899 (set 2)	0.342 (set 1)
H	1.267	2.156	1.604	6.721
I	1.063	1.725[a]	3.188	1.158
J	0.639	0.467[a]	0.888	0.645

[a]Saw first-cut delinters, abrasive second-cut delinters, otherwise all saw delinters.
[b]Sand reels only in operation; first-cut seed being processed.

TABLE II

Turnout per Ton of Raw Seed Processed

Mill	Oil	Meal	Hulls	1st-Cut delinters	2nd-Cut delinters	3rd-Cut delinters	Motes	Losses
A	310	930	540	29	96	–	–	95
B	N/A	N/A	N/A	N/A	N/A	–	N/A	N/A
C	330	931	404	31	– 162[a]	–	–	159
D	359	873	452	–	– 159[b]	–	–	121
E	320	910	470	85	100	–	–	115
F	340	940	460	35	135	–	5	85
G	343	901	547	54	– 107[c]	–	14	34
H	300	950	550	40	120	–	–	40
I	362	959	477	22	153	–	–	27
J	295	937	502	63	102	–	–	101
Avg	333	926	489	d	d	d	d	86

[a]129 lb combined second- and third-cut linters, 33 lb fourth-cut linters.
[b]All grades linters combined.
[c]Second- and third-cut linters combined.
[d]Average not calculated due to combined linter products in some mills.
N/A: not available.

seed were analyzed for moisture content and particle size distribution and the time-weighted average dust concentration as determined by the elutriators was calculated. A preliminary report describing these findings was sent to management for factual correction. In no case was any attempt made by the personnel of any mill to change the sampling results of the reported observations and comments regarding the general status of their mill with regard to emissions.

Housekeeping and Maintenance

In several oil mills visited, obvious maintenance problems existed. These were: rough bearings on fans feeding the cyclones, worn conical cyclone sections, and numerous places in which ductwork had been repaired with tape or bagging. In those cases where excessive cyclone or ductwork wear was observed, a harder steel should be used for all points subjected to excessive erosion.

Other housekeeping practices which would result in the immediate reduction of dust in the respirable range would be the elimination of all blow-through (positive pressure) air handling systems and their conversion to negative pressure systems. This is being done on a replacement basis in many of the mills.

High pressure air was used to blow dust from most of the machinery in many of the mills visited. This practice does not eliminate, but rather increases, respirable dust in the working environment. In some situations, attempts are being made to remove this nuisance and fugitive dust by vacuum techniques and by floor sweeps as well as sweeping or shoveling up gross amounts of trash from the floor for recycle to the process. Light-weight, extensible tubing with light-weight nozzles on the end can and should be procured for vacuum cleaning the machinery and motors in elevated locations so that blow-down can be totally eliminated as a work practice.

From the data collected, the best control technology in current use was selected based on elutriated dust concentrations and soundness of engineering design with regard to prevention of emissions. The conceptual design of the dust control system was then made and applied to a model mill with a capacity of 500 tons of raw cottonseed/day. This

TABLE III

Equipment Used in the Cleaning Room

Mill	Tons/day	Cleaners	Rock trap	Reclaim shaker
A	400	5	–	2
B	400	6	1	–
C	220	4	1	1
D	585	8	–	1
E	800			
F	750	12	–	–
G	600	9	1 (in 2 places)	1
H	300	4	1 (in 2 places)	–
I	400	7	–	–
Avg/100 tons		1.51	–	–
Ideal	500	8	1	1

TABLE IV

Equipment Used in the Delintering Room

		1st-cut saw			2nd-cut saw				3rd-cut saw		
Mill	Tons/day	12"	18"	Beater	12"	18"	2nd-cut abrasive	Beater	12"	18"	Mote beater
A	400	–	–	–	–	–	–	–	–	–	1
B	400	–	9	–	–	16	–	–	–	8	1
C	220	10	–	–	–	–	8	–	–	–	–
D	585	24	–	–	–	–	15	6[a]	–	–	–
E	800	–	–	–	–	–	18	–	–	–	–
F	750	38	–	2	80	–	–	8	–	–	–
G	600	30	–	–	30	–	–	–	25	–	–
H	300	–	8	–	–	16	–	–	–	–	–
I	400	18	–	–	–	–	11	–	–	–	–
Avg/100 tons		4.68	2.46		7.83	4.66	2.345				
Ideal	500	24	13	2	39	24	14	6	21	10	1 (Optional)

[a]Two batteries of 2 primary and 1 recycle beaters each.

report presents the analysis of the dust control systems, and the development of the dust control system for the model mill.

MODEL MILL

As shown in Tables III-VI, each of the first 9 mills visited was characterized with regard to raw cottonseed tonnage and the number and type of major processing equipment in use. From these data, an average number of processing elements per hundred tons of raw cottonseed was computed. From these data, the extrapolation to the 500 tons/day model mill was made. After obtaining a preliminary design in this fashion, it was evaluated by the Engineers Committee of the National Cottonseed Products Association and various other engineers employed in the manufacture of cottonseed oil mill equipment. After the resulting refinements, the model mill was as shown in Figure 1. In all figures, multiply og 0.9144 or 0.02832, respectively, to convert ft to m or cfm to m^3/min.

In the model mill, all optional components are shown by dashed lines. The proposed floor plan for the model mill is shown in Figure 2. The bulk seed are stored in a raw seed tank and from there are conveyed into the cleaning room. En route, the raw seed can be passed through a rock and shale trap to remove rocks and other large trash. Some linters and fine dust are aspirated from the rock and shale trap. The seed leaving the rock and shale trap are conveyed to a surge bin and are then distributed into 8 seed cleaners. The raw seed surge bin and overflow bin are installed above the reclaim shaker and are aspirated as observed in some mills with low respirable dust levels. The concept of this design is to remove the respirable dust and lint fly as early in the process as possible.

Considerable amounts of dust are emitted from all levels of the cleaner-shakers. The heavy trash produced from the top shaker trays is conveyed to a reclaim shaker where some white seeds are recovered and returned to the white seed surge bin between cleaners and the first-cut delinters. Dust and trash can be aspirated from the cleaners and routed through an optional cyclone which exhausts to the atmosphere. The bottoms from the cyclone go to a mote beater. Motes are either baled separately or combined with first-cut linters, as needed.

Seed leaving the cleaners go into white seed surge bin and are then conveyed into the first-cut delinters. For the 500 ton/day raw seed capacity, it is estimated that 13 saw-type, 18-in. delinters are required. The fugitive dust emitted from the delinters can be controlled to some extent by use of a cyclone robbing system. Removal of particulate matter by vacuum draw-off above the mote belt reduces the possibility of fugitive emissions downstream in the linter product line.

The first-cut seed are routed directly to second-cut

TABLE V

Equipment Used in the Hulling/Separating Room

Mill	Tons/day	Safety shaker	Huller & shaker	Decorticator	Hull/seed separator	Double drum beater	Single drum beater	Purifier	Tailings beater
A	400	–	–	–	–	–	–	–	–
B	400	–	6	–	–	3	–	–	1
C	220	1	2	1	3	–	–	1	1
D	585	1	8	–	4	4	1	3	–
E	800	1	9	–	–	–	–	–	–
F	750	2	6	2	6	4	2	2	1
G	600	1	7	–	7	4	–	2	–
H	300	–	4	–	–	3	1	4	1
I	400	1	5	1	–	4	–	2	1
Avg/100 tons		–	1.08	–	–	–	–	–	–
Ideal	500	1	5	4	4	4	1	3	1

TABLE VI

Equipment Used in the Bale Press Room[a]

Mill	Tons/day	1st-cut	2nd-cut	3rd-cut	4th-cut	Motes
A	400	–	–	–	–	On 1st-cut
B	400	1	–	–	–	On 1st-cut
C	220	–	–	–	–	–
D	585	–	2	–	–	–
E	800	–	–	–	–	–
F	750	1	1	1	–	1
G	600	–	1	1	–	1
H	300	1	1	–	–	–
I	400	1	1	–	–	–
Avg/100 tons	–	–	–	–	–	–
Ideal	500	1	1	1	–	–[b]

[a]Number of presses depend on type of press and cycle time.
[b]On first-cut press (or use 2 double presses).

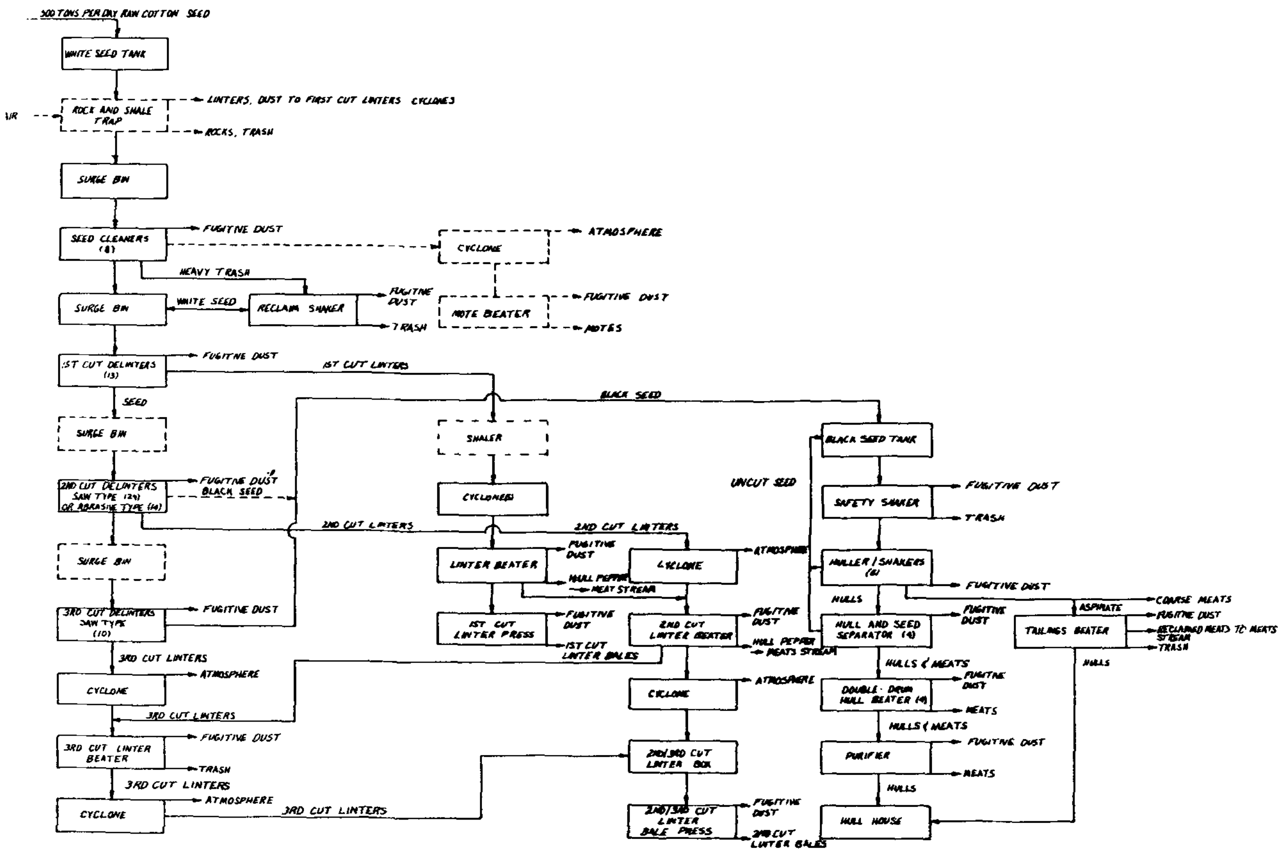

FIG. 1. Flow scheme for model mill.

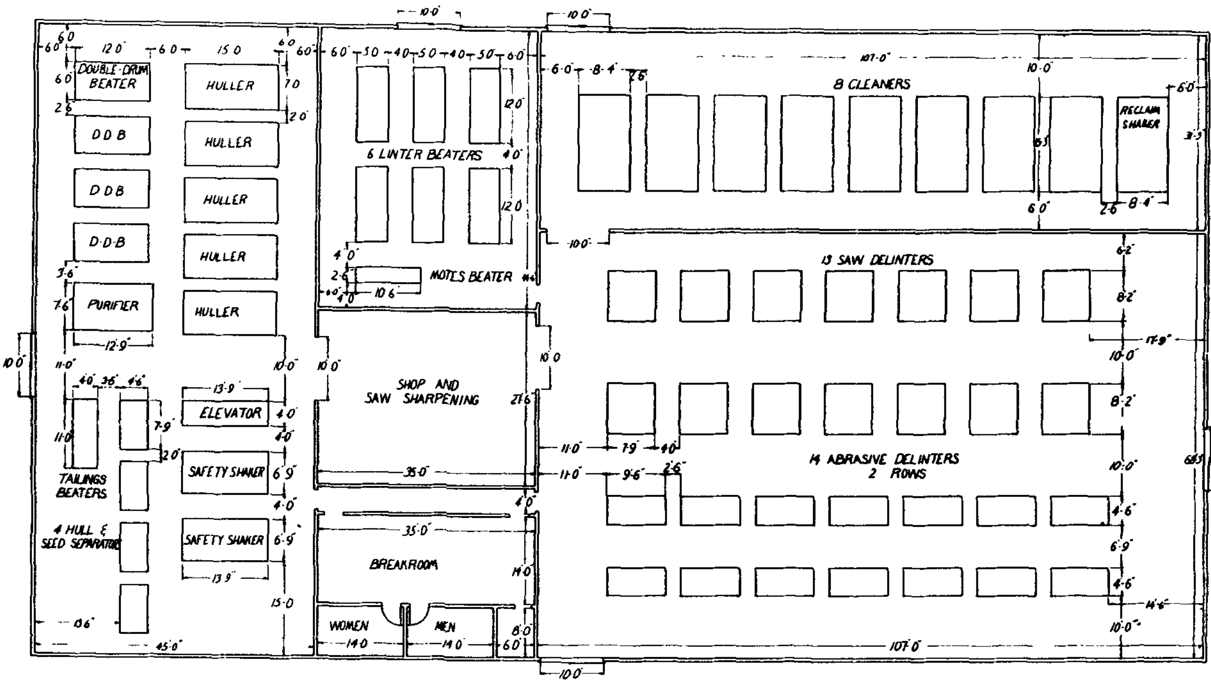

FIG. 2. Floor plan for model mill. Note: all exterior walls and interior partitions not to scale. All interior doorways 3'-0" wide unless otherwise specified. Fourteen saw delinters shown therefore spacing optional.

delintering. The first-cut linters are collected by a negative pressure cyclone battery and then sent to a linter beater. The linters from these beaters are conveyed by a negative pressure system to the first-cut linter bale press. Fugitive dust is emitted from both the linter beater and the linter press.

Other than fugitive dust, 2 material streams leave the linter beaters: second-cut linters and hull pepper. Either 24 saw-type, 18-in. or 14 abrasive second-cut delinters can be used. Second-cut linters are blended with reclaimed linters from the first-cut linter beaters and are collected by negative pressure cyclones for delivery to the second-cut linter beaters. From those beaters, the linters are collected by a negative pressure cyclone and dropped through a vacuum box or lock hopper into the second-/third-cut linter press. The second-cut linters are usually combined with third-cut linters for baling. Seed leaving the second-cut saw delinters are conveyed to an optional surge bin and then to the third-cut saw delinters (if desired). Third-cut linters are treated very much the same as the second-cut linters.

The black seed from third-cut saw delintering or second-cut abrasive delintering are conveyed to surge (black seed) tanks and then to the safety shakers in the hulling room where trash is removed. A considerable amount of fugitive dust is emitted from the safety shakers. From the safety shakers, the black seed are sent to 5 hullers where they are mixed with recycled, uncut seed from the huller shakers and hull and seed separators. Fugitive dust is emitted from the hullers, the shakers, and the hull and seed separators. Coarse meats are removed from the huller shakers and are conveyed to the tailings beater. The reclaimed meats are combined into the meat stream and are ready for extraction preparation. The hull product from the tailings beater is conveyed to bulk hull storage by a negative pressure system.

The hulls leaving the huller shakers are aspirated with the uncut seed to the 4 hull and seed separators. From there, the hulls are sent to 4 double-drum beaters. The meat fragments recovered as a primary product from these beaters are combined with the rest of the meat stream from extraction preparation. The fine hull and meat fragments are conveyed to the purifier for further separation. Meats recovered from the purifier go in the meats stream whereas the hull fragments go to bulk hull storage. The coarse meats stream leaving the huller shakers is aspirated to remove fine meat fragments, hull particles and trash. The coarse meats then go directly to extraction preparation. The material removed by aspiration is sent to the tailings beater for recovery of fine meats and hull pieces. The reclaimed meats are combined into the meats stream for extraction preparation.

The layout of the model mill conforms to common practices observed in the industry as suggested by members of the NCPA Engineers Committee. The dust control system reflects current practices of respirable dust control currently in use in cottonseed oil mills. It is recognized that many mechanical seed handling equipment operations have been placed into buildings not specifically constructed as the model mill and that there are many configurations with each having its specific benefits, advantages and limitations.

RECOMMENDED DUST CONTROL SYSTEM

Fugitive dust is emitted from virtually every item of equipment in the cleaning, delintering, hulling and baling areas in cottonseed oil mills. An effective dust control system throughout the dry-process portion of the mill must be used to avoid exposing the mill employees to excessive respirable cotton dust concentrations. Recommended modifications to the machinery and product waste-handling systems to improve control of occupational dust levels are described in this section.

It must be emphasized that these recommended control systems represent the best state-of-the-art control technology observed. Installation of such occupational dust control systems does not guarantee meeting the cotton dust standard formerly proposed by OSHA for cottonseed oil mills

(1). Rather, installation should allow the dust levels in the model mill to be controlled to at least the same extent as those already encountered in the best-controlled mills evaluated in this study. Application of this technology to existing cottonseed oil mills can be expected to decrease the elutriated (and nuisance) dust levels. It would be unrealistic to expect that compliance with the proposed OSHA standard would be achieved.

Design Calculations

The flow rates, in cubic feet per minute (cfm), shown on the underlined Figures 3, 8, 14, 15, 26 and 29 are those calculated for proper cotton dust capture and transport through the corresponding sections of the ductwork system for each area of the model oil mill. Ductwork numbers shown on these figures are the same as those shown in a paper by Burford et al. (2). These calculations were made by use of a program developed for a hand-held calculator as described elsewhere (5).

Design Criteria

Basic assumptions have been made to assist in the respirable dust collection systems calculations. These are: (a) a negative pressure emission capture system is used throughout to decrease the elutriated dust levels in cottonseed oil mills; (b) standard air has a density of 0.075 lb/ft^3 at 70 F, 29.92 in. Hg barometric pressure and 50% relative humidity; (c) the radius of all elbows is 2.50 times the duct diameter. This gives a loss in inlet velocity pressure of 22% for 90° elbows, 15% for 60° elbows and 11% for 45° elbows; (d) all branch entries are at 30° from the main trunk line. This results in a velocity pressure entrance loss of 18% in the branch line; (e) the main trunk line in each section discharges into a cyclone collector. The air effluent from the cyclone is processed by a baghouse with the fan located downstream from the baghouse. The fan is equipped with a tapered stack (evase) to regain static pressure prior to discharge; (f) canopy hoods are used over all shakers, modified to fit around and evenly over the motors used to the unit. A maximum of 4 in. of clearance beneath the edge of the hood has been assumed. The edge of the hood nearest the material inlet would ideally be sealed to the equipment; however, for calculations, this seal was not considered; (g) the draw-offs for conveyors and other equipment that use similar design have been designed to have an angle of 60° with the horizontal; (h) all pipe used in the system is round and considered smooth. The heights of the main trunk systems above the floor are assumed to be: 20 ft for the cleaning and linter rooms, 30 ft in the bale room, 15 ft in the hulling room and 25 ft in the beater area; (i) movable hoods are connected by flexible lines to the system to allow a minimum of 6 ft clearance above the equipment. When the hoods are in place, these flexible lines will be tight so that static pressure losses are minimized. A correction factor for very rough pipe (6, p 6-30) was used to correct for the addition of the flexible duct. The hoods are suspended by wire cable over ceiling-mounted pulleys, counter-weighted and designed to lift out of the way for clearance of chokes and solution of mechanical problems. Guide rods are installed on the shaker frames for stability and control when the hoods must be lifted; (j) the capture velocity, V_C, is 100 ft/min in the huller/separator and cleaning rooms and 200 ft/min in the linter and press rooms. The ideal transport velocity in the ducts is 3,500 cfm with 3,000 cfm as minimal acceptable velocity; (k) duct work enlargements and contractions have an angle of 15° maximum or 1 unit change in diameter for every 5 units change of length, whichever gives the longest transition; and (l) the system has been designed as a balanced system without blast gates. However, each hood or branch should be equipped with a blast gate for pressure-balancing on the system or for emergency shut-down purposes. All duct work has been sized to reduce static pressure losses to minimum and to decrease the size of the fan.

Design Procedure

The systems were drawn to scale in plan, elevation and isometric views to determine the routing and length of each duct. The velocity pressure method (6, sections 1, 4 and 6) was then used to design the occupational dust control system in terms of the required air rate at each aspiration point or hood.

Cleaning Room

The seed-cleaning rooms in some mills had no provision for occupational dust control. In others, local exhaust was used at high dust emission plants followed by cyclones. In a few cases, final air purification was achieved by fabric filtration. In one mill, the cleaners were semi-enclosed as a dust control measure. The degree of effectiveness of these occupational dust control methods was evaluated by: use of the time-weighted respirable dust concentrations as listed in Table I, visual observations of nuisance dust and the associated housekeeping problems and by comparing the feasibility of the various approaches in current use.

The cleaning room dust control system for the model mill is shown in Figure 3. Starting at the left, 8 cleaners are shown followed by a reclaim shaker. The raw seed surge bin and overflow bin are located above the reclaim shaker (Fig. 4, not shown). Duct numbers are shown circled; underlined numbers here, as in subsequent figures, are cfm of air used for the dust control equipment. It is recommended that all conveyors and elevators between the raw seed tanks and the cleaners should be hooded and provided with vacuum draw-offs to remove the dust released by seed discharge. Section A-A′ in Figure 4 is a side view of the dust control hood for the reclaim shaker. Section B-B′ (Fig. 5, not shown) is a side view of the control hoods for the raw seed conveyor and elevator. Section C-C′, Figure 6, is a side view of a typical dust control canopy hood for cleaners and

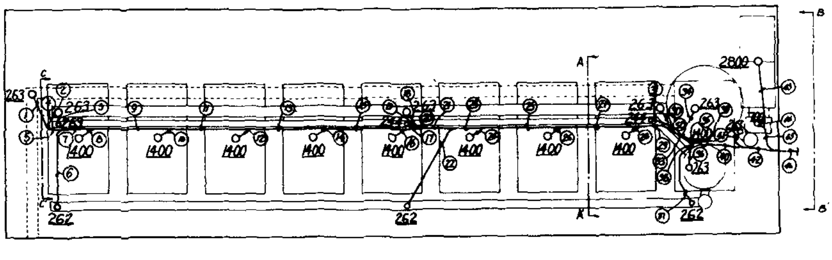

FIG. 3. Proposed dust collection system for model mill cleaner room. Note: all volumetric flow rates (Q) are in CFM. ① indicates duct number.

reclaim shakers with the hood in the raised position. A properly designed and curtained canopy hood with adequate clearance and overhang similar to that shown in section C-C′ is shown in Figure 7 and should be installed above each seed cleaner. It should be noted that all hoods over cleaners or shakers of any type must be provided with guide rods, suspended by cable from ceiling-mounted pulleys and counter-weighted (by the walls, for safety considerations). In this way, the hoods, connected to the main air trunk line by a section of flexible, noncollapsing (interiorly supported by wire springs) ductwork, can be raised for maintenance and choke clearing.

The sides of each cleaner should be covered with PVC strip-curtains suspended from the hood to provide reasonable enclosure and free access to the cleaners, yet allow air to be admitted into the cleaner at floor level (4 in. clearance) to sweep up and around the trays and into the hoods for dust removal. These strip curtains should be hung in 2 rows of overlapping layers (like shingles on a roof) around the front (Fig. 7, above and behind the top tray discharge trough) and both sides of the cleaners. The addition of a side-draft hood at the discharge end of the shaker trays further aids in dust control. The reclaim shakers should be hooded and curtained in the same manner.

Linter Room

The approaches to occupational dust emission containment in this area have included slot hoods above the linter feed rolls to control inlet process air velocity, and assorted cloth, plastic, or wooden closures around various parts of the saw-type delinters. As abrasive delinters are totally enclosed, no dust control measures were observed in those processing areas. Dust emissions from delintering were invariably captured by cyclones followed by, in about one-third of the mills visited, fabric filtration for final air cleanup. The layout for the linter room is shown in Figure 8. Section A-A′ (Fig. 9, not shown) includes the white seed elevator, white seed surge tank, and the delinter feed and recycle conveyors with vacuum draw-off at all material transfer points. Section B-B′ (Fig. 10, not shown) gives similar information for the second-cut delinters and the first-cut seed surge tank feeding the second-cut delinters.

Dust control equipment in the delintering area must not interfere with removal of the delinter saws for sharpening and yet be positioned as close to the emission sources as possible for maximal capture efficiency with minimal air volume. Spring-loaded metal flaps should be installed at the feed roll discharge to prevent any blow-back of dust emissions into the working environment. For saw-type delinters, a suction line above the feedroll should be installed above the flap to capture any dust not contained by the flap. Figures 11 and 12 (not shown) have side and front views of the slot-type receiving hoods used on saw-type delinters just above the inlet feedroll. Metal or wooden covers should be provided at the seed discharge to reduce noise and fugitive dust emissions, provide adequate linter capture velocity into the linter flue system and act as a safety precaution.

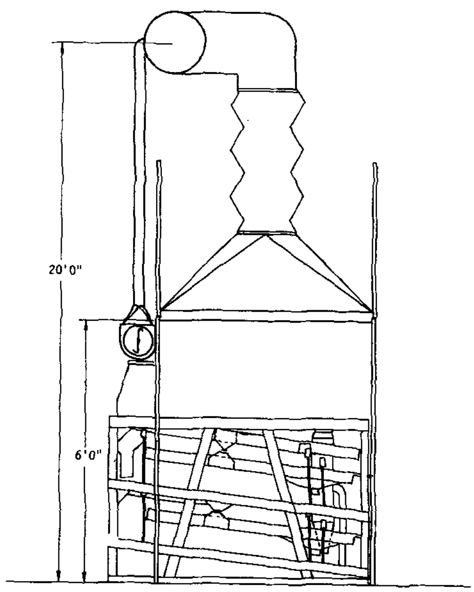

FIG. 6. Section C-C′ side view of typical dust control hood for cleaners and reclaim shaker. Hood shown in raised position.

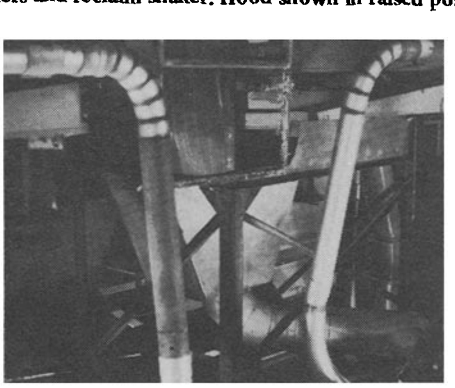

FIG. 7. Dust capture hood above seed cleaner.

Beater Room

For all linter beaters, properly designed aspiration hoods should be installed to capture fugitive dust emitted at the feed and at the various product discharge points. Figure 13 (not shown) gives a side view of a typical 3-stage beater with aspiration at the inlet feed, product discharge, and bottoms discharge points. The proposed dust control system for the model mill linter beater room is shown in Figure 14. The small circles represent top views of the aspiration ducts given in Figure 13 for fugitive emission control.

Hulling/Separating Room

Dust control systems in use in this area of cottonseed oil mills which were visited ranged from none to fairly extensive. In several mills, vacuum aspiration was provided at the huller feed rolls, at the inlet to the double-drum beaters and

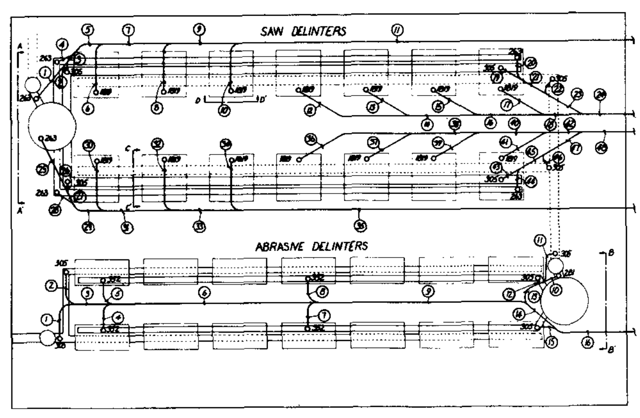

FIG. 8. Proposed dust control system for model mill linter room. Note: all volumetric flow rates (Q) are in CFM. ① indicates duct number.

at the inlet to the purifier and tailings beaters. A canopy hood was installed over the safety shakers in one mill. In other mills, cloth drag-sheets on the top huller-shaker tray were the only attempt made to control dust. The safety shakers, purifier, and all huller shakers should be hooded and equipped with PVC side-strip curtains as shown in Figure 7. Vacuum draw-offs for dust removal should be installed at selected points on the conveyors feeding the hullers, hull and seed separators, and all beaters in this processing area. Aspiration should also be provided at the hull beater and purifier feed and discharge points to capture fugitive dust emissions from those sources. A dust control system for the hulling/separating room in the model mill is shown in Figure 15. Section A-A′ (Fig. 16, not shown) is a typical aspiration duct at a conveyor transfer point in the hulling room. Similar aspiration should be provided at every material transfer point when conveyors are involved. Section B-B′ (Fig. 17, not shown) gives a typical dust control aspiration hood for the huller feed conveyor and a canopy hood on a flexible connection above the huller shaker in the raised position. Guide rods are at the sides of the canopy hood. For proper operation, these hoods should be suspended by a wire and pulley system from the ceiling and counter-weighted. Sections C-C′ (Fig. 18, not shown) and D-D′ (Fig. 19, not shown) give, respectively, side and end views of the recommended vacuum draw-off for the feed conveyor to double-drum beaters. Section E-E′ (Fig. 20, not shown) has the canopy hood above a purifier in the raised position. This hood, as those above the huller shakers, is attached to the branch duct by means of a flexible coupling. Section F-F′ (Fig. 21, not shown) gives an end view of a tailings beater equipped with vacuum draw-off for dust control. Section G-G′ (Fig. 22, not shown) is a side view of the hull and seed separator showing the proposed dust control hood on the feed conveyor. Section H-H′ (Fig. 23, not shown) is a side view of the safety shaker with canopy hood in raised position on its flexible coupling. This safety shaker is also equipped with vacuum draw-off on the feed conveyor. Section I-I′ (Fig. 24, not shown) illustrates the hoods proposed for controlling dust emissions at material transfer points in the huller, elevator and surge bin and for the huller feed conveyor and black seed recycle conveyors. Section J-J′ (Fig. 25, not shown) illustrates the black seed elevator and surge bin dust control aspiration points.

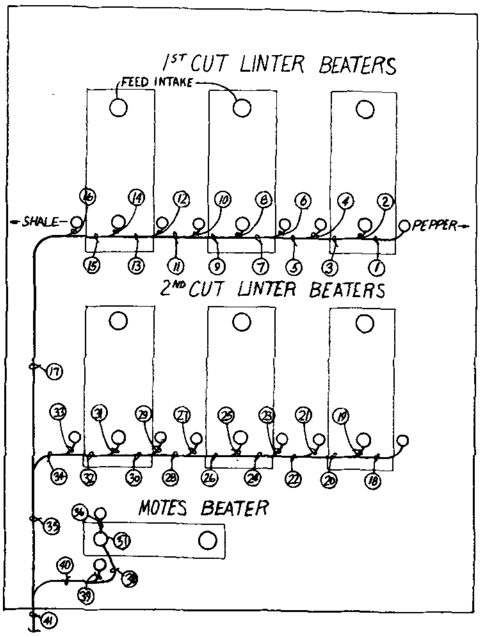

FIG. 14. Proposed dust control system for model mill linter beater room.

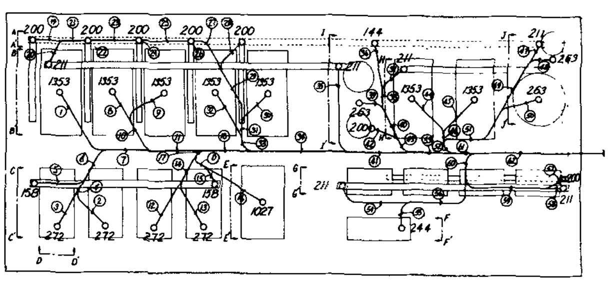

FIG. 15. Proposed dust collection system for model mill huller room. Note: all volumetric flow rates (Q) are in CFM. ① indicates duct number.

Baling Room

The majority of the fugitive dust in this area is produced by the bale presses. Aspiration ducts should be installed at each place where such emissions occur. Almost all the bale presses observed during the course of this study were equipped with some combination of floor sweeps at the operating level and in the tramper pit, and with vacuum draw-offs around some of the emission points on the press itself. Our approach to dust control in this area is simple: aspiration ducts should be installed at each place where emissions occur. These are: below the linter chute, at the top of the tramper box, at floor level above the press box, and by the linter box. Floor sweeps should also be provided to pick up loose lint and trash. Figure 26 (not shown) gives the proposed dust control system floor plan for the model mill press room. Figures 27 and 28 (not shown) are schematic diagrams of dust capture points on a typical press. Figures 29 (not shown) and 30 (also not shown) give the floor sweep layout for the press room of the model mill.

Final Air Cleanup

All dust emissions collected from the cleaning, delintering, hulling-separating and baling areas should be routed to separate negative pressure cyclone batteries outside the building. The cyclone exhaust should be conveyed to a fabric filter baghouse for final control rather than being simply discharged to the atmosphere. This will preclude the conversion of occupational dust problems into air pollution

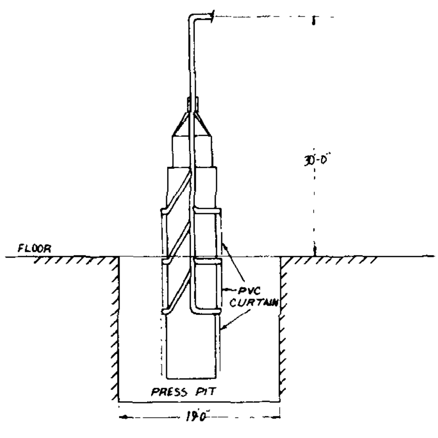

FIG. 27. End elevation of bale press dust control system.

problems.

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The comments and recommendations made in this report reflect the opinions of the authors and should not be construed to reflect endorsement or policy of the Department of Agriculture.

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Economics of Occupational Cotton Dust Control in Cottonseed Oil Mills

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ABSTRACT

An economic analysis of the total cost for various dust control systems for a 500 ton/day model cottonseed oil mill has been performed. All cost data have been adjusted to reflect May 1981 prices. Cost data are presented for the dust collection system, cyclone(s), baghouse(s) and prime air mover(s) for each major processing area at 3 different air-to-cloth ratios. Data were obtained for equipment and installation costs from mills using the various devices and/or complete systems wherever possible. In cases where these data were not available, estimates were obtained from several firms that manufacture and install similar equipment. At the recommended air-to-cloth ratio of 20:1, the initial capital cost was estimated as $707,900, the annual operating expenses as $226,490 and the life cycle cost as $607,510.

INTRODUCTION

This paper presents an estimate of the total cost for the dust control system for a 500 ton/day model cottonseed oil mill previously described (1). In these calculations, it was assumed that the mill would operate 24 hr/day, 330 days/yr. Specifications of various segments of the dust control system were distributed to several manufacturers and suppliers (2-8) who customarily build and install such equipment for various segments of the raw cotton industry. With minor exceptions as noted later, prices as of mid-May 1981 were obtained and used in preparing this economic analysis. For the purpose of estimating the total pressure losses in the dust control systems, the pressure drop through a cyclone battery was estimated as 2.5 in. of water, through woven filter bags as 4 in. of water and through felted filter bags as 5 in. of water. These estimates are consistent with current technology.

DELIVERED EQUIPMENT COSTS

Cyclones and Accessories

The procedure for estimating the cost of cyclones and accessories has been described elsewhere (9). The cost of the cyclone is based on the size of the inlet area, type and thickness of the steel used and the cost of supports and dust hoppers (dust arrestors). In general, multiple cyclones cost the same as an equal number of single units of the same size. The use of an involute, rather than a tangential, entry for a cyclone increases the basic equipment cost by 10%. Because this increase in cost is more than offset by a corresponding increase in operating efficiency and a decrease in static pressure loss through the cyclone, involute entries were selected for use with all cyclones in these dust control systems. Costs for screw conveyors for removing collected dusts from the cyclone bottoms were not included in this economic analysis as those portions of the installations will vary among mills, depending on, e.g., existing dust control provisions and product handling systems.

Fans and Motors

At most of the oil mills visited during this research, centrifugal fans directly powered by electric motors were used to transport dust-laden air through the dust control system. There are 2 basic types of fans: the backward-curved fan and the radial-tip fan. The backward-curved fan, used for negative pressure systems, provides higher efficiency. It must be used downstream of the dust control system where the airstream is relatively dust-free. Radial-tip fans were selected as they are typically used in the raw cotton industry. The cost of such fans is based on type, actual flow rate, class and pressure drop at standard conditions. The prices of the motor and the starter are functions of the fan speed, total system pressure, air flow rate and selected motor housing.

Ductwork, Hoods and Dampers

The cost of ductwork (ducts, elbows, wyes, dampers, hangers and clamps) is a function of the duct diameter and metal thickness. Hoods are priced according to outside dimensions and metal thickness. Ten-gauge carbon steel was chosen for use uniformly throughout these systems. The cost of ductwork, elbows, wyes, hangers, flexible tubing and counterweight systems and strip curtains for hoods were obtained between May and August 1981 from vendors (2,5,6,8,10,11). These data were used as obtained without